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CENTRIFUGAL TIDES.

BY PROF. ASAPH HALL.

THE earth and the moon move in ellipses around their common centre of gravity, the time of revolution being 27.32166 days. If we take the mass of the earth as the unit of mass, the mass of the moon will be $m = \frac{1}{81}$; and the centre of gravity will be 2912 miles from the earth's centre, and 6875 miles from the farther side of the earth. Let a be the distance of the moon from the centre of the earth, and take the radius of the earth for the unit of distance; then the difference of the attractions of the moon on the centre of the earth and on opposite points of its surface will be,

$$\frac{m}{(a-1)^2} - \frac{m}{a^2} = \frac{m(2a-1)}{a^2(a-1)^2}$$

$$\frac{m}{a^2} - \frac{m}{(a+1)^2} = \frac{m(2a+1)}{a^2(a+1)^2}$$

Since $a = 60.257$, if we neglect the units we have for the approximate value of this difference $2m \div a^3$. Now the attraction of the moon on a point of the earth's surface ninety degrees from the line joining the centres tends to increase the attractive force of the earth on this point, and it is found that the preceding expression becomes $3m \div a^3$.

If we call m' the mass of the sun, and a' its distance from the earth, we have likewise $3m' \div a'^3$ for the difference of its attraction on the centre of the earth and on a point where the line joining the centres meets the earth's surface. Also

$$m' = 324439; \quad a' = 23340.9$$

Turning these expressions of the disturbing force into numbers we find that the ratio of the moon's disturbing force to that of the sun's is 2.212; and that the combined disturbance of the sun and moon on a point of the earth's surface situated on a line joining their centres is only 0.0000002458 of the attraction of the earth on the same point.

The general expression for the centrifugal force is $v^2 \div r$; v being the velocity of the particle and r the radius of curvature of its orbit. If t expressed in seconds be the time of the revolution of the earth around the centre of gravity we have

$$t = 2360591.4$$

$$v = \frac{2\pi r}{t}.$$

The centrifugal force is therefore $r \cdot \left(\frac{2\pi}{t}\right)^2$. If we express r in feet, $r = 6875 \times 5280$; and if we notice that the earth's gravitating force measured in the same way is 32.2, we find for the centrifugal force 0.000008024. The centrifugal tidal force is therefore nearly 33 times as great as the combined tidal force of the sun and moon, and should produce an enormous tide sweeping over our seaboard cities. But we know that no such tide exists. Will some one therefore point out the fallacy of the above reasoning. Such an investigation will not be useless, since the centrifugal theory of the tides is such an attractive one that it is frequently given in books on popular astronomy, and it is continually coming up in our popular scientific journals and at the meetings of our scientific associations.

[Because the centrifugal force of a particle moving in a circle, under the influence of an attracting body, is a function of the velocity of the particle and of the radius of curvature of its path; therefore the centrifugal force can only vary with the variation of one or both of these elements. But in the revolution of the earth about the common center of gravity of the earth and moon there is no rotation of the earth about that center; therefore in this revolution all points of the earth move in similar and equal curves, and the radius of curvature of these curves is not $r = 6875$ miles but, approximately, $r = 95,000,000$ miles; for the earth, in consequence, moves around the sun in a disturbed ellipse. And in this disturbed orbit, though the centrifugal force of the earth varies slightly at conjunction and opposition of the sun and moon in consequence of a variation in its radius of curvature and velocity at those periods, all its parts move with the same velocity and in parallel curves; therefore this disturbance can have no effect on the tides except through the variable attraction of the sun and moon.

The fallacy, manifested by the result in the foregoing argument, consists therefore in the application of the formula $r \left(\frac{2\pi}{t}\right)^2$, by which it is virtually assumed that the earth revolves around the common center of gravity of the earth and moon, as the moon does, making one rotation on its axis while it completes one revolution in that orbit.—Ed.]

CORRESPONDENCE.

EDITOR ANALYST:

I notice you inquire in "*Science*", as to the evidence of the conversion of gravitation into heat and light. Are not the nearest approaches to a demonstration of such convertibility, the following?